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REPORT ON PIPELINE NOISE STUDY

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INTRODUCTION

Shallow Bay and Kugmallit Bay are the two areas used most extensively during summer by beluga whales in the Mackenzie estuary. This herd has been estimated at numbering up to 4,000 animals. These bays open earlier than the surrounding Beaufort Sea, and their waters become much warmer than the open ocean. Due to the warmer water temperatures, most calving and nursing for the Mackenzie herd takes place within these bays. While the herds are in the bays, native whalers traditionally harvest between one and two hundred belugas each year for subsistence purposes (F. F. Slaney & Co., 1973, 1974, 1975).

The wide auditory range of marine mammals is well documented. Hall and Johnson found that a captive killer whale (*Orcinus orca*) could detect underwater sounds between a frequency range of 500 Hz and 32 kHz, and with sound pressure level as low as -70 dB (at 15 kHz re 1 dyne per sq. cm.). The auditory range of beluga whales (*Delphinapterus leucas*) has not been determined, but its vocal nature has long been known (Banfield, 1974). In captivity at the Vancouver aquarium, belugas have shown two distinct types of vocalization. One group of sounds ("clicks") is used for social purposes; it has a frequency of about 20 kHz. The other set of clicks has its maximum intensity at about 48 kHz, and its upper limit might range as high as 150 kHz, although 60 kHz is a more likely figure. These are echolocation clicks, and may be used in navigation or locating food (Dr. Beza Fisher, Department of Zoology, UBC, pers. comm.).

In the wild, belugas show very definite reactions to specific sounds. The sounds of outboard motors (used by native hunters) frighten whales, but they show no alarm at engine noises from gravel barges (Slaney, 1975, p. 45). However, whales will move to a safe distance when confronted by an unknown sound, and if this sound blocks off an escape route, they panic. If the sound is unvarying and stationary, whales will become curious and accustomed to it (Slaney, 1974, appendix 9).

Residents of Aklavik, who harvested about 25 whales in 1974 (Slaney, 1975), have expressed concern that noise associated with gas flowing through submarine pipelines in Shallow Bay would frighten whales and disrupt whaling activities.

A literature search revealed little information concerning noise levels associated with gas transmission through the pipe of a pipeline. Field experience indicated that any noise in the line was associated with valves, constrictions, and bends. The objective of the present study was to measure the frequency and intensity of any sounds associated with a lined, large-diameter gas pipeline at a major river crossing.

METHODS

The field measurements of sound intensities were made at the TransCanada Pipelines Red River crossing on July 31, 1975. The river is about 200 yards wide at the crossing, and the bottom is largely silt. The study site was on the west bank, and sound measurements were taken just off the bottom in two to three feet of water. Figure 1 shows the crossing.



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At the time of the study, the river was approaching a flood stage. The maximum depth of water at the crossing was about ten feet.

Four gas pipelines cross the Red River at the right-of-way. Site plans showed that lines 100-1 and 100-2 were made of internally coated 34 inch O.D., .500 inch wall thickness steel pipe, cleaned, primed, double coated, and wrapped. Concrete river weights were bolted to the pipe to achieve negative buoyancy. Lines 100-3 and 100-4 were made from lengths of internally coated 42 inch O.D., 0.371 inch wall thickness steel pipe. Concrete coatings had been used to weight the pipe. The depth of cover was not marked on the site plans, but employees at the nearest compressor station mentioned that the pipe was buried two to three feet beneath the ground. At the west bank of the Red River, all four lines jogged about 20 degrees to the south before passing under the river. At the east bank, the line curved northward, so that it paralleled the original track.

The closest upstream compressor station was at Portage La Prairie, about 50 miles west of the river crossing. The prime movers were all gas-fired turbines, and their power was about 45,000 hp. The nearest downstream compressor station was Ile de Chenes, about 7 miles away. Here the compressors were powered by reciprocating engines and turbines. Station personnel reported that the Cooper-Bessemer piston engines caused a pinging sound audible for several miles downstream; this was not evident at the Red River crossing.

The sound measuring equipment consisted of a Hewlett-Packard spectrum analyzer (HP 141T mainframe, 8552 LF portion, 8556 RF portion) and a calibrated hydrophone with preamplifier (Celeco LC-32). This package was capable of detecting sound power levels as low as -80 dB (where 0 dB = 1 milliwatt; -80 dB = 10^{-11} watts) between the frequencies of 20Hz and 100 kHz. The response of the analyzer was tested before the field measurements were conducted, and it was satisfactory. Figure 2 shows the instrument package.

At the river crossing, the hydrophone was held just off the bottom in two or three feet of water. The actual locations of the pipelines could be determined by the condition of the river bottom: the bottom was much softer over the width of the filled ditch. At each line, a number of analytical combinations (scan time, bandwidth, frequency range) were used until the clearest display of the sound spectrum was achieved. This was sketched and photographed.

RESULTS

Figures 3 and 4 depict typical cathode ray tube traces of sound levels over the pipelines. No significant difference existed between noises from the concrete coated lines and the wrapped, weighted lines. Figure 3 shows a typical spectrum up to 100 kHz. Each division along the X-axis represents 10 kHz, while the topmost horizontal division represents a reference sound power level of -40 dB. Most of the trace is along the -80 dB line. Major peaks occur at 2 kHz, 14 kHz, and a larger peak at 40 kHz. This last maximum coincides with a random incidence peak on

the calibration curve of the hydrophone. Smaller peaks, regularly spaced along the -80 dB line, reflect the scanning bandwidth of the instrument. It integrated the amplitude of all wave functions over a three kHz bandwidth to a central frequency. The sound power level of -74dB at 10 kHz is anomalous; it did not occur on any other traces. The other peak, hardly visible on this trace, is in the lower range of the audible spectrum.

Figure 4 depicts the sound system up to 10 kHz for the same pipeline as shown in Figure 3. The bulk of the trace, from 4.0 to 10.0 kHz, is aligned along the horizontal line representing -80 dB, the lower threshold of the instrument. Each vertical division represents 1.0 kHz. There is a broad band of noise up to a frequency of 3.7 kHz, with a maximum power level of -70 dB. A smaller distinct peak is present at about 0.5 kHz. In this display, the flat trace reflects the small scanning bandwidth used in the analysis.

DISCUSSION

These observed results in the 0 to 10 kHz range correlated well with predicted values (H. Purcell, pers. comm.). Further observations confirmed the hypothesis that this band of noise was associated with gas transmission. When measurements were taken in the water away from the pipeline, no significant disturbances with a frequency higher than 1.0 kHz were observed. Low frequency noise (with a frequency less than 1.0 kHz) was present, and, as it was common to all investigations, it probably resulted from river turbulence.

From this investigation, gas flowing through pipelines does create noise. However, this noise is insignificant. The highest sound power level found during the study was approximately 10^{-10} watts, and this was evident only directly over the pipeline. As a measure of comparison, a person speaking in a very soft whisper generates about 10^{-9} watts, or -60 dB (Peterson and Gross, 1972, page 6). Attenuation in the water was extremely rapid, and this noise was not discernible a few feet away from the pipeline. Some of this broad band noise undoubtedly originated from the nearby bend in the pipe so that noise levels would be lower for a straight section of a pipeline. In any case, the frequency of this noise rules out any possibility for interference with the activities of beluga whales in Shallow Bay.

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